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ORIGINAL PAPER

Long-term outcomes of the revision open lumbar discectomy by fenestration: A follow-up study of more than 10 years

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Abstract A total of 51 patients who underwent the second open discectomy by fenestration from January 1988 through December 1994, were followed for an average of 146.8 months. The long-term follow-up results were evaluated through direct examinations and questionnaires. At the final follow-up, according to the Macnab classification an excellent and good outcome was achieved in 70.6% of the cases, and 78.4% were satisfied with their results. The failure rate was 15.7% (8 patients). Excluding those 8 failed cases who needed another reoperation, the average improvement calculated by Japanese Orthopaedic Association (JOA) scores was 64.6%. Factors that were associated with a fair and bad outcome included smoking, isolated trauma or injury, fibrosis and the duration of the remaining or recurrent primary postoperative symptoms. We noted that psychosociological signs were probably negative predictors of lumbar disc surgery outcome. Because the revision operation is typically associated with a higher complexity, selection of suitable surgical candidates and determination of valid indications for operative treatment are very important.

Résumé 51 patients ont bénéficié d'une réintervention (deuxième intervention pour discectomie) entre janvier 1988 et décembre 1994 et ont été suivis en moyenne 146,8 mois. Les résultats à long terme ont été évalués après un questionnaire et un examen. Au suivi final 70,6% présentaient un excellent ou bon résultat suivant la classification de MacNab, 78,4% étant satisfaits de leur résultat. Le taux d'échec est de 15,7% (8 patients). Si l'on exclut ces huit patients qui ont nécessité une nouvelle réintervention, l'amélioration moyenne calculée selon le score de la JOA a été de 64,6%. Ces facteurs associés avec un mauvais résultat ou un résultat médiocre sont les patients fumeurs, les lésions post-traumatiques, les phénomènes de fibroses, un long délai entre la réintervention et l'intervention primaire. Les facteurs sociologiques sont souvent perçus comme des facteurs négatifs compte tenu du fait que la révision est souvent complexe, il est donc nécessaire de bien sélectionner les patients à réopérer avec des indications bien solides.

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Introduction

For more than 50 years, standard discectomy (SD) has been used to manage lumbar disc herniation (LDH) worldwide. Although many new technologies emerged and have gained attention in recent years, SD is still the preferred management technique among the majority of spine surgeons, and its favourable outcomes have been reported [5–8, 13, 17–19, 21–23]. The rate of revision after a lumbar discectomy is a recognised objective measure of the failure of primary surgery and is included in many outcome studies. A recurrent herniation after a lumbar discectomy has been reported in 18% of the patients and depends on the duration of the follow-up [2, 7, 9, 14, 18–20, 23].

The rate of necessary repeat interventions following primary discectomy ranges between 4 and 18% [2, 6–9, 14, 19, 20]. However, the surgical options for the treatment of recurrent lumbar disc herniation (RLDH) are not standardised. There is also an ongoing debate about the superiority of repeat disc excision alone or disc excision with fusion, and less invasive decompressive procedures [1, 8]. The long-term results of surgical intervention are of

great interest to us [4, 5]. Very few studies have focused on analysing the long-term results of repeat SD on true recurrent disc herniation [5]. We performed a retrospective evaluation of the long-term outcomes of recurrent LDH patients who underwent revision discectomy by fenestration (RDF) with a minimum follow-up period of 10 years, to address such postoperative problems. Whether this technique would also be suitable for recurrent herniations was unclear until now. In theory, it would be an advantage since it entails less invasive trauma and does not require general anaesthesia. Our hypothesis is that RDF is a safe and effective treatment method for RLDH patients.

Patients and methods

A total of 74 consecutive patients who underwent a revision discectomy from January 1988 to December 1994 in our department were investigated retrospectively. Inclusion criteria for this study were (1) at least 6 months of pain relief after primary disc surgery, (2) the presence of recurrent radicular pain unresponsive to conservative treatment, so that a repeat operation was undertaken, and (3) a true recurrent lumbar disc herniation. True recurrent disc herniation was defined as an ipsilateral disc herniation evident in imaging studies and during repeat surgery at the same level as the primary discectomy. Cases with recurrent disc herniation with concomitant spinal disorders such as spinal stenosis or instability were excluded. Of the 74 patients, we were able to evaluate the recovery process after more than 10 years following the operation in 51 (68.92%) cases. The study group was composed of 38 men and 13 women, whose ages at the time of surgery ranged from 20 to 71 years (average age: 42.2 years). The follow-up period ranged from 120 to 203 months (average: 146.8 months). The levels of RLDH were L3-4 in one case, L4-5 in 31 cases, and L5-S1 in 16 cases. Three patients had herniations at two levels: L4-5 and L5-S1. Therefore, the total number of discs involved in this study was 54. A questionnaire was sent to all 51 patients and they completed it. They were asked about their employment status, and patient satisfaction.

All patients had a history of a sudden onset of recurrent radicular pain and a positive straight leg raising test. Conservative therapy, including medication, epidural block, traction, and orthosis, had failed for at least 2 months in all of the patients operated on for radicular pain. At the preoperative examination all patients clearly presented a radiological picture of lumbar disc herniation using myelography, computed tomography (CT), and/or magnetic resonance imaging (MRI). MRI with gadolinium enhancement was conducted for diagnosis in 34 cases, CT was performed in 10 cases, myelography in 7 cases, and CT concomitant with myelography in 3 cases.

Revision discectomy by fenestration

Surgery was performed by three surgeons using standardised techniques consisting of interlaminar fenestration followed by herniotomy. All of the revision surgeries were performed from the original site of the recurrent disc herniation. The lamina was removed partially whenever necessary, and the recurrent herniation was removed after retracting the nerve roots. Using a curette, the epidural scar tissue at the previous laminotomy area was separated from the margin of the lamina. Access to the normal anatomical planes of the epidural space was achieved by removal of the lamina to the point at which the epidural scar tissue was detached and by partial resection of the scar tissue enclosing the dural tube. Occasionally, the nerve root adhered to the extruded disc fragment or to the ligamentous structures and required sharp dissection for separation.

The amount and extent of fibrosis and dural ectasia were evaluated before reoperation in the lumbar spine region. We defined the proximal and distal end of the fibrosis before embarking on separating it from the dural layer. If the scar tissue is not likely to cause compression after adequate deroofing, it may be left adherent to the dura.

Preoperative and postoperative outcome evaluation

We evaluated the clinical results according to the Macnab classification system [15] and the JOA score (Japanese Orthopaedic Association's evaluation system for low back pain syndrome) [11]. The JOA score was determined *via* direct questioning to assess subjective symptoms, clinical signs, and restriction of activities of daily living. The normal score was 29 points. An improvement in JOA score was calculated as follows: improvement (%) = (postoperative score-preoperative score)/(29-preoperative score). Clinical symptoms and scores were assessed both before surgery and at the final follow-up. Surgery outcomes were assessed based on the recovery rate and were classified using a Macnab four-grade scale: excellent, good, fair, and poor improvement. The excellent and good categories of the Macnab classification were noted as "success"(group1); otherwise, fair and poor were noted as "failure" (group2).

Statistical Analysis

The SPSS mathematical program was used and the data were evaluated by an unpaired Student's *t*-test, Pearson's chi square test, Fisher exact probability test, and multivariate logistic regression analysis. A significance level of 0.05 was selected for univariate analyses and 0.10 was selected for multivariate analyses. All statistical calcula-

tions were carried out by SPSS version 13.0 for Windows (SPSS, Inc., Chicago, IL, USA).

Results

General clinical outcome, based on the Macnab scale, was excellent in 25 (49.0%) patients, good in 11 (21.6%), fair in 7 (13.7%), and poor in 8 (15.7%) at the final follow-up. All eight patients with poor results underwent further revision surgery. Success was achieved in 70.6% at the final follow-up. According to the final outcome described as "success" and "failure", patients were divided into two groups. The characteristics of the patients are summarised in Table 1. Preoperative JOA score, duration between the primary and the revision operation, length of symptom relief after primary surgery, length of symptom episode after primary surgery, number of RLDH cases combined with fibrosis, presence or absence of complications, sex, age at the operation, body-mass index (BMI), smoking, and injury history, and were all thought to be potential determinants for improvement of JOA scores.

The percent of smokers in group1 was significantly less than in group 2(36.1% vs 73.3%, $P<0.05$). The length of symptom episode after the primary SD in group 1 and 2 were 7.5 and 12.9 months, respectively ($P<0.05$). More than half of the patients in group2 had an injury history (53.3%) after the primary SD and fibrosis or scar tissue (80%) which was confirmed by radiological and operative findings. Both were significantly higher than in group1 ($P<0.05$). However, there was no significant difference in other variables between groups 1 and 2. A logistic regression analysis with "success" or "failure" result based on the Macnab scale as the dependent variable and the above 11 factors as independent variables revealed that 4 factors were significant (Tables 2, 3). Smoking and injury history significantly affected the long-term prognosis of RDF independently, the odds ratio for the failure results of RDF in smokers and patients with an injury history were 3.6 and 4.2, respectively. Fibrosis and length of symptom episode after the primary surgery were combined to affect the final results. Fibrosis increased the risk 5.9 times when compared with those who did not have fibrosis or scar tissue; and the risk of failure increased by 12.5% for each additional 1 month of symptom episode.

JOA scores at the final follow-up were not calculated in those eight patients with poor results who received further revision surgery. The average JOA score of the remaining 43 patients at the final follow-up assessment are listed in Table 4. Overall, the 43 patients showed a significant clinical recovery. Overall improvement of JOA scores at the final follow-up was 64.6%. After the revision operation, their scores significantly increased from 9.6±2.5 to 22.2±3.5 ($P<0.01$) at the final follow up.

Occupation of the patients was also considered in this study. The questionnaire revealed that in group1, 7 patients (19.4%) returned to the same job, 4 (11.1%) changed their job, 9 (25%) retired, 8 (22.2%) were out of work, and 8 (22.2%) were farmers; in group2, 4 (26.7%) retired, 2 (13.3%) changed their job, 6 (40%) were out of work, and 3 (20%) were farmers.

Table 1 Summary of patient profile (values are mean±SD, number and percent)

Patient data	Group 1 (n=36,70.6%)	Group 2 (n=15,29.4%)	P
Ratio of males to females	26:10	12:3	0.730
Age at second operation (years)	42.3±11.0	42.0±7.0	0.936
BMI(kg/m^2)	23.6±2.2	23.7±2.8	0.901
Cigarette smokers	13 (36.1%)	11 (73.3%)	0.029
Time between two operations (months)	42.8±45.1	44.4±35.9	0.905
Length of symptom relief after primary surgery (months)	35.4±42.4	31.5±30.6	0.749
Length of symptom episode after primary surgery (months)	7.5±4.8	12.9±10.6	0.014
Injury history	6 (16.7%)	8 (53.3%)	0.014
Preoperative JOAscore	9.8±2.5	8.5±2.2	0.098
Number of RLDH cases combined with fibrosis or scar	17 (47.2%)	12 (80%)	0.031
Complications	5 (13.9%)	3 (13.3%)	0.733
Dural tear	2	3	
Nerve root injury	2		
Deep infection	1		

Discussion

A simple discectomy of a frankly prolapsed or sequestrated disc that is causing significant leg pain or neurological deficit, or both, however, provides extremely gratifying results for management of pain in the short to medium term. Complete removal and a thorough search for herniated disc material is essential when carrying out the initial operation for LDH [1]. Following disc excision, a RLDH at the same

Table 2 Forward logistic regression

	Odds ratio	SE	z	$P>\|z\|$	95% confidence interval	
Injury	4.231778	3.038492	2.01	0.045	1.035965	17.28625
Smoker	3.599096	2.574393	1.79	0.073	0.8858057	14.6234

Table 3 Backward logistic regression

	Odds ratio	SE	z	$P>\|z\|$	95% confidence interval	
RLDH Combined with fibrosis or scar	5.94109	4.861888	2.18	0.029	1.194774	29.54245
Length of symptom unrelief after primary surgery	1.12599	0.0582624	2.29	0.022	1.017398	1.246174

site or from an adjacent disc can occur in up to 10% of patients [1, 8, 18–20, 23]. The optimal surgical approach for RLDH remains a subject of controversy. Baba and co-workers [1] reviewed 45 patients who had undergone repeated open operations for LDH with a mean follow up of 4.3 years. Good to excellent results were obtained in 64%. They found that removal of as much as possible of the remaining nucleus and annulus, but with minimal invasion of the posterior elements, was crucial for improving the outcome of revision surgery. Those who had a first-time revision had earlier improvement and better results. Fu et al. [8] evaluated the results of repeat surgery for RLDH, and compared the results of disc excision with and without posterolateral fusion. They revealed excellent or good clinical outcomes in 78.3% of patients who had RDF alone and in 83.3% of patients with posterolateral fusion. Although the patients in the fusion group tended to have better outcomes than those with disc excision alone, the difference in the recovery rate between these two groups was insignificant. Some studies also reported that the clinical outcome was good with repeated decompression alone [1, 2, 12, 19, 20]. This viewpoint was confirmed by the long-term follow-up data in our study, which reveal good to excellent results in 70.6% of patients and the average recovery rate in this study exceeded 50%, which is comparable with these respective rates in other short or medium follow up studies.

Revision spinal surgery is more challenging owing to the peridural fibrosis or scar tissue [8]. But a direct cause–effect relationship between clinically significant pain and the peridural scar tissue has not been established [6]. Jönsson and Strömqvist [12] found significantly poor results for reoperation of the lumbar spine after decompression surgery in patients with fibrosis at revision surgery. Furthermore, they reported deterioration in the clinical results with time in these patients with peridural fibrosis. On the other hand, Nygaard et al. [16] found no correlation between the amount of fibrous tissue and patient outcome following revision surgery. Cinotti et al. [2] found that scar tissue quantity was not related to surgical outcomes, and suggested that following the removal of the disc fragment, the epidural scar does not cause residual radicular pain. In our study, peridural fibrosis was found to be combined with the length of symptom episode and correlated to clinical outcomes. It seems that the poorer outcomes may be not only from the difficulty encountered while operating around scar tissue but also from the scar itself. The authors believe that a sufficient amount of experience and ability is required to operate around the dura and nerve roots in the presence of fibrosis and it is important to evaluate the amount and extent of fibrosis preoperatively by MRI augmented by gadolinium. Intraoperatively, the coexistence of disc fragments and peridural fibrosis was found in 29 (56.9%) cases. The scar tissue was not routinely excised completely.

The effects of nicotine have been studied in animals and vascular changes, tissue hypoxia, and degeneration of the intervertebral discs as well as changes in gene expression and histologic changes in the discs have been shown [10, 13]. Tobacco smoke inhalation increased local production and release of inflammatory cytokines and resultant decomposition of chondrocyte activity [17]. A weak positive association with the incidence and prevalence of non-specific back pain was found in most studies. This study confirmed the correlation between smoking and poor results after RDF. The percent of smokers in group 2 was much higher than in group1 ($P<0.05$). Back injury was associated with an increased risk of disc degeneration [6]. This study also found that RLDH was precipitated by injury, and the risk of worse prognosis increased in patients with a history of injury.

This study showed severe socioeconomic and psychological problems in some RLDH patients. In group 2, 6

Table 4 Results assessed by JOA score (n=43; Mean±SD)

JOA score (points)	Subjective ymptoms	Clinical signs	Restriction of activities of daily living	Bladder function	Total score
Preoperative	3.05±1.02	1.56±1.05	5.60±1.28	-0.63±1.23	9.56±2.48
Postoperative	6.65±1.45	4.79±1.19	11.07±1.28	-0.35±0.97	22.16±3.50
Recovery rate	64.6±18.2%				

(40%) patients were unemployed. Life pressure and emotional stress increase the risk of lumbar degeneration and low back pain. Mental stress appeared to occur as a function of time pressures on task performance and resulted in less controlled movements and increases in trunk muscle coactivation [3]. These adjustments significantly increased spine loading. These results suggest a potential mechanism for the increase in low back pain risk resulting from psychosocial stress caused by modern life pressures in developing countries.

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